CELLULAR MANUFACTURING

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Introduction

- Cell is a product centered grouping of machines and workers with all the resources to meet defined objectives
- How to form a cells?

a. Cell formed around a whole process flow chart

b. Cell formed around a convenient part of a process flow chart

c. Single product cells

d. Multi product cell – to make products sharing a substantially similar product route (group technology)

e. Dedicated customer cell

f. High volume/low variety cell

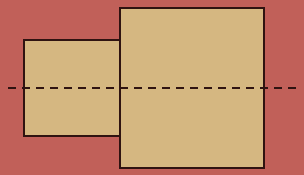
g. Low volume/high variety cell

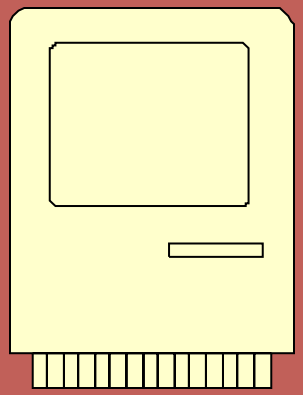
h. Prototype cell

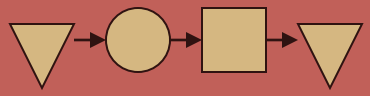
Introduction

- Most common: flow concept – get material in, through and out in shortest possible time
- Engineering elements required:

Product Equipment Workflow







Introduction

- The characteristics of cells

1. Self contained (with all the resources needed to make the cells products)
2. Close proximity of equipment, simple material routing and handling
3. Centralised functions such as maintenance, manufacturing engineering and quality control carried out within the cell
4. Job flexibility, multi-skilling, team working, responsibility for quality, ownership of problems and their solutions
5. Customer – supplier links between cells
6. Continuous improvement ethos
7. Flexibility and responsiveness to customer needs through small batch, short lead-time capability

Defining Cells

- Machines, tasks, processes and products can be grouped together by a number of different methods
- Single Product – high volume and flow line
- Product Flow Analysis (PFA)

  - Technique which examines the existing product flow routes under a process layout organisation

  - Looks for similarity of process route as a basis for machine group and product families

  - King's Method

Defining Cells

- Product Flow Analysis (PFA)

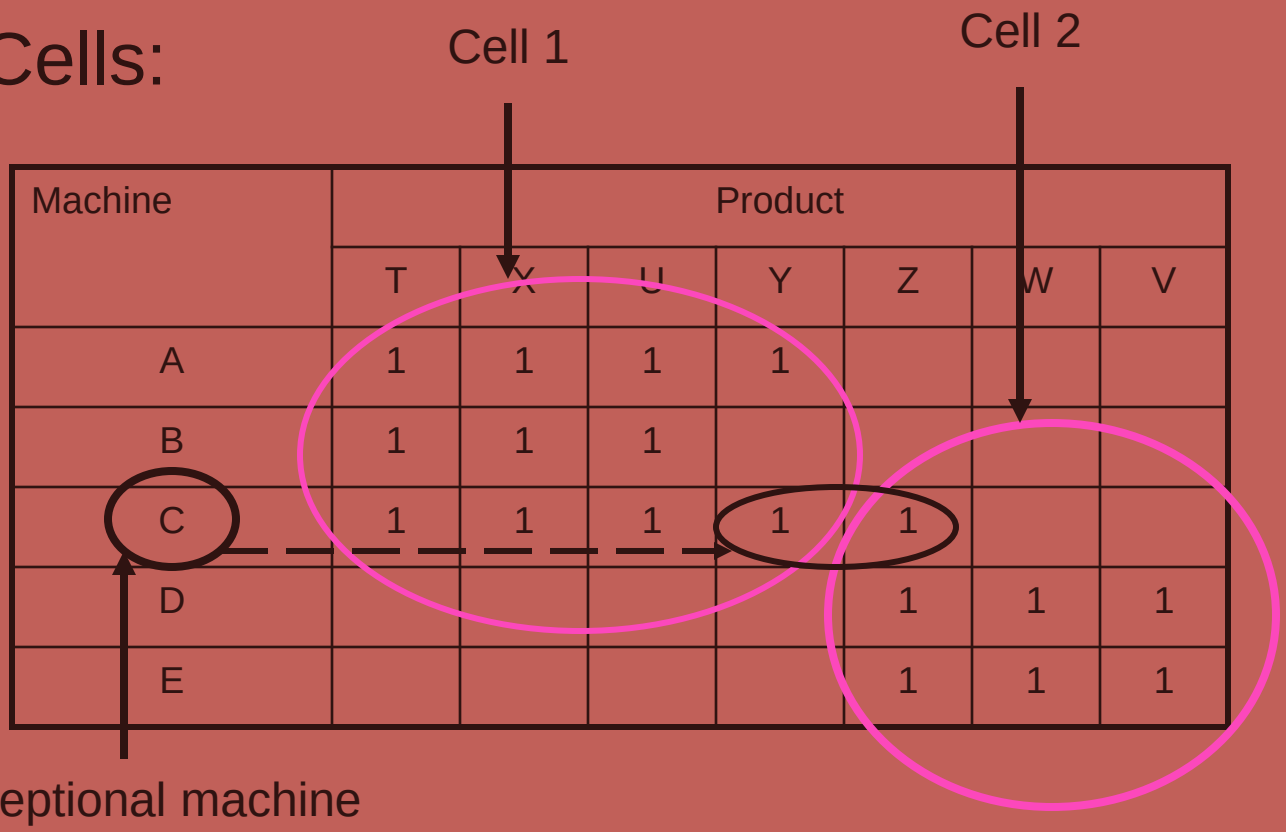
  - Example:

Product	Volume	Process Routing (Machine Sequence)
T	12000	A – B – C
U	9500	C – B – A
V	8000	E – D
W	6000	D – E
X	2400	A – B – C
Y	1000	C – A
Z	800	C – D – E

Defining Cells

- Product Flow Analysis (PFA)

  - Cells:



Defining Cells

- Product Focused – formed around the product
- Customer focused – grouped to satisfy on individual customer eg. Rolls Royce turbine blade manufacturing cells
- Materials – product grouped around material properties will often have similar machining constraints and will benefit from manufacture in a cell containing similar products eg. Light alloy

Defining Cells

- Process Sequence Cells (PSC)

  - Cells are constructed from all the machine required to perform stages of operations for all the products

  - Each cell not dedicated to a product but rather to a stage in the sequence

  - Enables high variety products

Defining Cells

- Process Sequence Cells

  - Example:

Product	Operation Sequence (Machine)
P1	B, A, D
P2	A, C, E, D
P3	B, C
P4	A, E, B
P5	B, C, D, E
P6	C, B
P7	B, A, C, E

Defining Cells

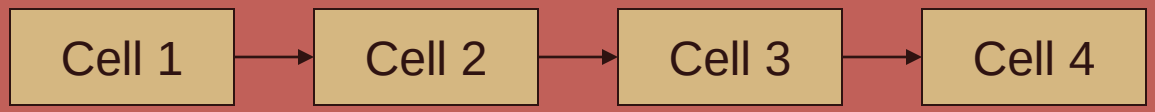
- Process Sequence Cells
  - Analysis:

Product	Last but 3 operations	Last but 2 operations	Last but 1 operations	Last operation
P1		B	A	D
P2	A	C	E	D
P3			B	C
P4		A	E	B
P5	B	C	D	E
P6			C	B
P7	B	A	C	E

Defining Cells

- Process Sequence Cells

  - Cells:



Machine???

Techniques

- King’s Method
- Process Sequence cells

Cluster Analysis (King's Method)

- Production flow analysis (PFA) chart
- Classification of objects based on their possession
- Based on rank order analysis developed by J. R. King (King's Method)
- King's Method designed to generate diagonally based groupings of the PFA chart entries

King's Method

- Matrix which indicates which machines operate on which parts

MACHINES \ PARTS	A	B	C	D	E	F
MILL		X		X	X	X
JIG	X		X		X	
GRIND		X		X		
EDM				X		
LATHE	X		X	X	X	
WELD			X		X	
LASER		X		X		X

King's Method

- Binary analysis (64,32,16,8,4,2,1) for rows (machine)

MACHINES	PARTS A	B	C	D	E	F	Decimal	Rank
MILL	0	1	0	1	1	1	23	3
JIG	1	0	1	0	1	0	42	2
GRIND	0	1	0	1	0	0	20	5
EDM	0	0	0	1	0	0	4	7
LATHE	1	0	1	1	1	0	45	1
WELD	0	0	1	0	1	0	10	6
LASER	0	1	0	1	0	1	21	4

King's Method

- Column (parts)

MACHINES	PARTS A	B	C	D	E	F
LATHE	1	0	1	1	1	0
JIG	1	0	1	0	1	0
MILL	0	1	0	1	1	1
LASER	0	1	0	1	0	1
GRIND	0	1	0	1	0	0
WELD	0	0	1	0	1	0
EDM	0	0	0	1	0	0
Decimal	96	28	98	93	114	24
Rank	3	5	2	4	1	6

King's Method

- Result

MACHINES \ PARTS	E	C	A	D	B	F
LATHE	1	1	1	1	0	0
JIG	1	1	1	0	0	0
MILL	1	0	0	1	1	1
LASER	0	0	0	1	1	1
GRIND	0	0	0	1	1	0
WELD	1	1	0	0	0	0
EDM	0	0	0	1	0	0

Note:

Cell1

Cell 2

Exceptional element

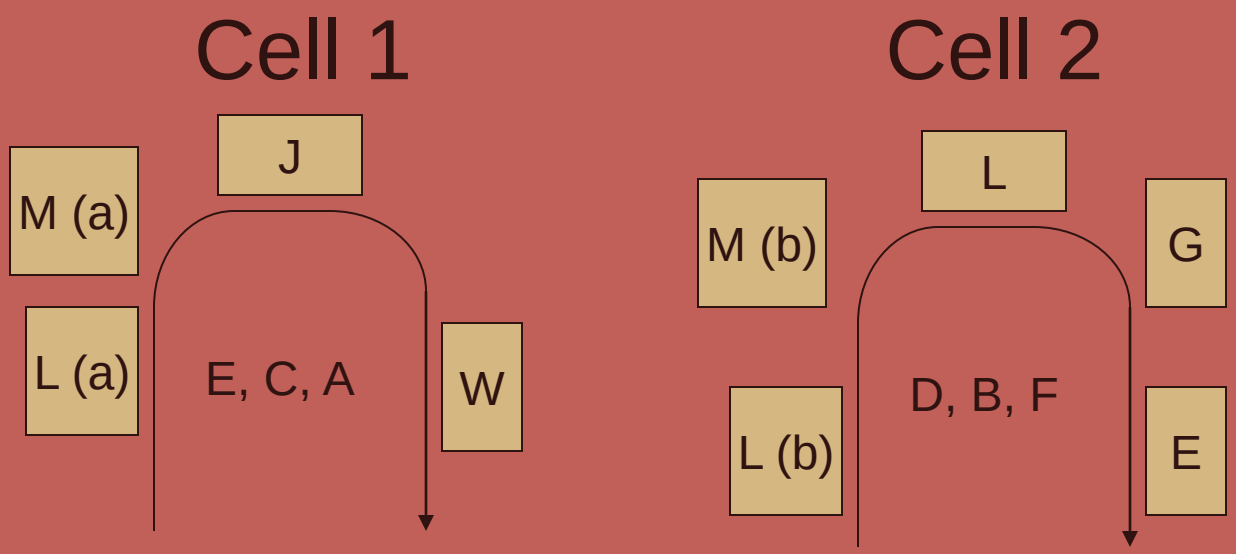
King's Method

- Cell 1: Parts: E, C, A

  Process: Jig, Weld
- Cell 2: Parts: D, B, F

  Process: Laser, Grind, EDM
- Exceptional Element: machine needed in both cells (Lathe, Milling machine)

King's Method



King's Method

- Practical steps for coping with exceptional element are:

a. Duplicate machines
b. Re-plan the operation to another machine in the cell
c. Sub-contract the operation
d. Transfer to another cell with proper scheduling

Class Exercise

- The following route cards describe how parts A, B, C, D, E, F and G are manufactured. By using the cluster analysis program, show how these can be assigned to manufacturing cells

Class Exercise

Operation	Machine	Description
Part A		
OP 10	Grind	Grind side faces
OP 20	V. Mill	Mill top face
OP 30	H/T	Harden
Part B		
OP 10	Jig Bore	Bore center hole
OP 20	Drill	Drill hole
OP 30	H. Mill	Mill side faces
OP 40	Inspect	Final inspection
Part C		
OP 10	Grind	Grind top faces
OP 20	V. Mill	Mill side face
OP 30	H/T	Harden

Class Exercise

Operation	Machine	Description
Part D		
OP 10	Drill	Drill holes
OP 20	Jig Bore	Bore center holes
OP 30	H. Mill	Mill top faces
OP 40	Inspect	Final Inspection
Part E		
OP 10	Grind	Grind top face
OP 20	Drill	Drill centre hole
OP 30	H/T	Harden and temper
OP 40	Inspect	Final inspection

Class Exercise

Operation	Machine	Description
Part F		
OP 10	Grind	Drill holes
OP 20	Jig Bore	Bore center holes
OP 30	Drill	Drill side holes
OP 40	H. Mill	Mill top face
OP 50	Inspect	Final Inspection
Part G		
OP 10	Grind	Grind top face
OP 20	V. Mill	Mill side faces
OP 30	Jig Bore	Bore centre hole
OP 40	H/T	Harden and temper

Process Sequence Cells

Case Study

- Working condition: 1 shift, 7.5 hrs/day, 5 days/week, 48 weeks/year
- Annual demand for product 1, 2 and 3

Product	1	2	3
Monthly Demand	528	384	576

- Machine available

Machine	Number Available
Drill	2
Grind	6
Mill	4
EDM	6

Process Sequence Cells

- Production sequence (time in minute per piece)
- **Product 1**

Raw material store	
Mill	22.7
Grind	13.9
Drill	3.6
Grind	2.3
EDM	11.8 (6hrs change over)
Heat Treatment (off line)	2 hrs/batch (20mins-load and 20mins-unload, batch size 30)
Grind	5.9
Plating Treatment	6 hrs/batch (subcontractor, batch size 360)
Final Inspection	27.1

Process Sequence Cells

- **Product 2**

Raw material store	
Mill	18.9
Mill	4.8
Grind	17.2
Drill	2.1
Drill	3.9
EDM	5.7 (6hrs change over)
Heat Treatment (off line)	2 hrs/batch (20mins-load and 20mins-unload, batch size 30)
Grind	4.8
Grind	5.2
Plating Treatment	6 hrs/batch (subcontractor, batch size 360)
Final Inspection	27.1

Process Sequence Cells

- **Product 3**

Raw material store	
Grind	3.4
Mill	23.8
Grind	18
Drill	1.5
Drill	1.1
EDM	12 (6hrs change over)
EDM	6 (6hrs change over)
Grind	5.6
Heat Treatment (off line)	2 hrs/batch (20mins-load and 20mins-unload, batch size 30)
Grind	5.8
Plating Treatment	6 hrs/batch (subcontractor, batch size 360)
Final Inspection	27.1

Process Sequence Cells

Solution

- Monthly output for each product

Product	1	2	3
Monthly Demand	528	384	576

- Time available = 7.5 x 5 x 4

  = 150 hours/month/machine

- Heat treatment and plating treatment – not consider

Process Sequence Cells

- Sequence for each product

Product	Operation									
	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
1				M	G	D	G	E	G	F
2		M	M	G	D	D	E	G	G	F
3	G	M	G	D	D	E	E	G	G	F

Process Sequence Cells

- Time required per machine for each product per month (sample calculation)
- Product 1 (Milling)

Monthly output = 528 units

Operation time = 22.7 minutes

Total time = 528 x 22.7/60

= 200 hours

Process Sequence Cells

- Number of machine required (Product 1, Milling process)
  - = Time required/Time available
  - = 200/150 = 1.33 = 2 machines
- Utilisation (Product 1, Milling process)
  - = Time required / (No. of machine x Time available)
  - = 200/(2x150) = 67%

Process Sequence Cells

Detail results

Product	Operation									
	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
1				M 200	G 122	D 32	G 20	E 104	G 52	F 238
2		M 121	M 31	G 110	D 13	D 25	E 36	G 31	G 33	F 173
3	G 33	M 228	G 173	D 14	D 11	E 115	E 58	G 54	G 56	F 260
Total time Per machine	G 33	M 349	M 31 G 173	M 200 G 110 D 14	D 24 G 122	D 57 E 115	G 20 E 74	E 104 G 85	G 141	F 672
No. of m/c req	G 1	M 3	M 1 G 2	M 2 G 1 D 1	D 1 G 1	D 1 E 1	G 1 E 1	E 1 G 1	G 1	F 5
Utilise (%)	G 22	M 78	M 20 G 58	M 67 G 73 D 10	D 16 G 82	D 38 E 77	G 14 E 49	E 69 G 56	G 94	F 90

Process Sequence Cells

- From results, machine required
  - a. Milling = 6 machines
  - b. Grinding = 7 machines
  - c. Drilling = 3 machines
  - d. EDM = 3 machines
- Machine available
  - a. Milling = 4 machines
  - b. Grinding = 6 machines
  - c. Drilling = 2 machines
  - d. EDM = 6 machines

Process Sequence Cells

Cells determination

Product	Operation									
	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
1			M G		D			G E	G	F
2			M M G		D D		E		G G	F
3			G M G		D D		E E	G	G	F
Total time Per machine			M 580 G 438		D 95		E 209	E 104 G 74	G 172	F 672
No. of m/c req			M 4 G 3		D 1		E 2	E 1 G 1	G 2	F 5
Utilise (%)			M 97 G 97		D 64		E 70	E 69 G 46	G 57	F 90
Cell			1		2		3	4	5	6

Process Sequence Cells

- Number of machines required
  - a. Milling = 4 machines
  - b. Grinding = 6 machines
  - c. Drilling = 1 machines
  - d. EDM = 3 machines
  - e. Inspection = 5 operators

Nagare Cells

- One piece flow production system
- U shape layout